(Un)common knowledge: Children use social relationships to determine who knows what
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**Research Highlights**

- Children use social relationships to determine who likely has shared knowledge
- Children expect friends to share personal knowledge, such as secrets
- Children expect members of the same group to share cultural knowledge
- Selective social inferences about shared knowledge increase with age

**Abstract**

Socially savvy individuals track what they know *and* what other people likely know, and they use this information to navigate the social world. We examine whether children expect people to have shared knowledge based on their social relationships (e.g., expecting friends to know each other’s secrets, expecting members of the same cultural group to share cultural knowledge) and we compare children’s reasoning about shared knowledge to their reasoning about common knowledge (e.g., the wrongness of moral violations). In three studies, we told 4-to 9-year-olds (*N*=227) about what a child knew and asked who else knew the information: The child’s friend (Studies 1-3), the child’s schoolmate (Study 1), another child from the same national group (Study 2), or the child’s sibling (Study 3). In all three studies, older children reliably used relationships to infer what other people knew. Moreover, with age, children increasingly considered both the type of knowledge and an individual’s social relationships when reporting who knew what. The results provide support for a “Selective Inferences” hypothesis and suggest that children’s early attention to social relationships facilitates an understanding of how knowledge transfers—an otherwise challenging cognitive process.

**Keywords:** Social cognition; social relationships; knowledge
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Knowledge is power. Possessing information allows humans to competently interact with the complex world around them. For social agents, it is not only important to possess knowledge oneself, but it is also critical to know who is “in the know” and who is not. Indeed, effectively navigating social and communicative interactions requires understanding that some people know information that others may not. For example, if Alice is deciding whether to discuss Sam’s secret with Erica, it is important for Alice to know whether Erica already knows Sam’s secret. Exposing another’s private information can have devastating social consequences, so discussing the secret may be okay if Erica already knows it, but not if she doesn’t. One reasonable cue that people could use to predict other people’s knowledge is their social standing and their relationships with others. In our example, you may infer that if Erica and Sam are friends (rather than enemies), then Erica would be likely to know Sam’s secret. Here, we investigate if and when children begin to use social relationships to predict who has access to the same knowledge, and whether their predictions change based on the type of social relationship and/or the type of knowledge.

Young children can think about what others know. By preschool, children report that people with perceptual access to information (e.g., those who were in the room when an action occurred) are more likely to know that information (Hogrefe, Wimmer, & Perner, 1986). Indeed, by two-years-old, children use perceptual access to tailor their communication in order to make efficient and understandable requests (O’Neill, 1996). And, even before infants and toddlers communicate verbally, they understand that informed individuals use testimony (including emotional responses and pointing) to pass knowledge to ignorant individuals (see Harris & Lane, 2014 for review). As early as four to five years of age, children understand that a person’s experiences can lead to expertise (e.g., reporting that a doctor knows more about mending a broken bone than a car mechanic; Lutz & Keil, 2002), and they differentiate between this type of directly acquired knowledge (i.e., information gained from one’s own experience) and indirectly acquired knowledge (i.e., information gained via testimony; Lockhart, Goddu, Smith, & Keil, 2016). Children also evaluate a teacher’s identity when deciding whether to learn: They are more willing to accept new information from people who were previously accurate (e.g., Koenig, Clément, & Harris, 2004) and from people in their social group.
Thus, children are selective in whom they learn from, and appear to have an early developing understanding of at least some of the ways in which knowledge is gained, and who is likely to hold knowledge.

What’s more, young children have a sophisticated understanding of the social world; they have expectations about how social partners interact. Infants expect people with shared preferences to affiliate (e.g., Liberman, Kinzler, & Woodward, 2014), expect people to approach others who have helped them (e.g., Kuhlmeier, Wynn, & Bloom, 2003), and expect people from the same group to act alike (e.g., Powell & Spelke, 2013). With age, children continue to use social relationships to make inferences about how people will feel, act, and interact. For instance, by age four children think people should share more with friends and family than with strangers (Olson & Spelke, 2008) and think a friend will be upset on their friend’s behalf in the event of a conflict (Pietraszewski & German, 2013). In fact, there is a large literature detailing children’s understanding of the importance of friendship, and their early inferences about who is friends with whom (e.g., Afshordi, 2019; Bigelow, 1977; Furman & Bierman, 1984; Liberman & Shaw, 2017; 2018; 2019; Nurmsoo, Einav, & Hood, 2012).

Taken together, the previous literature has clearly established that children reason about other people’s knowledge states and about the importance of social relationships. But, past research has not examined the intersection of these domains to establish whether children expect people’s knowledge to vary based on their relationships. This is a key question—as highlighted above, keeping track of who knows what is a critical skill for social communication. Indeed, investigating third-party reasoning about how relationships impact shared knowledge (e.g., whether two people other than the child share knowledge) is particularly interesting because third-party reasoning requires a general and abstract understanding. Rather than relying on their own knowledge and their own relationships, to make third-party inferences children must think about the connection between knowledge and relationships in general: who knows what, and how did those people acquire their knowledge. Such a third-party understanding could improve children’s own first-person interactions. For example, a child might use a potential teacher’s relationships and group memberships to determine what that person could teach them, even when the child doesn’t have first-hand information about the teacher’s knowledge. The current research examines the extent to which children make inferences about who
has shared knowledge, and whether these inferences depend both on the kind of knowledge and on the type of relationship that the two people share.

One possibility is that children do not recognize that relationships influence whether people will share knowledge. Even with an ability to determine who knows what (e.g., mechanics know about cars), preschoolers may not monitor where, how, or from whom people acquire their knowledge. Indeed, preschool aged children are notoriously bad at source monitoring (e.g., Taylor, Esbensen, & Bennett, 1994), and are biased towards thinking that other people know what they know (e.g., Birch & Bloom, 2003). Thus, children may expect experts to know about their expertise, and may expect that there are some things that everyone knows, but may not expect social relationships per se to have any impact on knowledge. In this case, children may think it is equally likely for people to have shared knowledge, regardless of whether they are friends, siblings, groupmates, or enemies. We will call this possibility the “No Inferences” Hypothesis.

A second possibility is that children use relationships to predict knowledge, but only focus on closeness. For example, children may infer that the more time people spend together, the more likely they are to have shared knowledge. This “Closeness” hypothesis suggests that children have a heuristic that people who are close (e.g., friends) are more likely than people who are distant (e.g., strangers) to share any type of knowledge. That is, the hypothesis takes into account relationships, but not the type of knowledge being shared. This is not an unlikely possibility—in fact, adults overestimate how much knowledge they share with close connections: They make more egocentric errors when interacting with friends and spouses than with strangers (Savitsky, Keysar, Epley, Carter, & Swanson, 2011) and tend to think about their friends as being a part of their self (e.g., Aron, Aron, & Smollan, 1992; Tu, Shaw, & Fischbach, 2015). And, although young children expect people to share more with friends and siblings than with strangers, they do not differentiate between friends and siblings (Olson & Spelke, 2008; Spokes & Spelke, 2016). Thus, children may expect close partners to have more shared knowledge in all domains.

Instead of either of these possibilities, however, we endorse a third, which we call the “Selective Inferences” hypothesis. Under this hypothesis, children may recognize that the type of relationship that connects two people is predictive of the type(s) of knowledge those people are likely to share. For example, because friends engage in intimate interpersonal settings, they should be more
likely to share personal knowledge. But, just because friends are close, they may not share all of their knowledge. For instance, if friends are from different cultures, they may know and follow different traditions and norms. Indeed, children may be able to reason that because cultural knowledge is a product of being a member of the cultural group (e.g., it is learned in cultural settings or from group leaders), people from the same cultural group should share cultural knowledge, even if they do not personally know one another, and did not acquire the knowledge at the same time, or from the same person. What’s more, children could understand that some knowledge might not be linked to specific relationships at all, but might be known by everyone. In line with this possibility, by preschool, children expect people to share secrets selectively with friends (Liberman & Shaw, 2018), expect native speakers, but not foreigners, to know familiar songs (Soley & Aldan, in press), and expect common moral rules to be known by all children (e.g., Smetana, 1981). This past research provides hints backing the “Selective Inferences” hypothesis, but does not directly test it. We conducted three studies on children’s inferences about how relationships relate to shared knowledge.

To adjudicate among the three hypotheses (see Figure 1), we told children about three people: a main character who held pieces of knowledge, and two targets, who were each related to the main character in a different way. The pieces of knowledge that the main character held were (1) personal: a secret, (2) cultural: how to celebrate a holiday, and (3) moral: that hitting is wrong. We asked participants to assess whether each target possessed the same knowledge as the main character. If children do not use social relationships to reason about shared knowledge (the “No Inferences” hypothesis), they should respond similarly to all questions, regardless of the relationship or the type of knowledge. If children expect general closeness to guide shared knowledge (the “Closeness” hypothesis), then they should think that people who are socially close (e.g., friends) will be more likely than people who are less close (e.g., classmates) to share all pieces of knowledge. But if, as predicted, children instead understand that people in different types of relationships share different types of knowledge (the “Selective Inferences” hypothesis), then they would generalize the main character’s knowledge differentially depending both on the social relationship and on the type of knowledge. Specifically, children may infer that all people share moral knowledge (because moral knowledge is common knowledge), that people who are socially close, and interact interpersonally,
share personal knowledge, and that people from the same culture (independent of whether they know each other personally) have shared cultural knowledge.

**General method**

For all three studies, data were collected between May 2017 and July 2017. 1 Participants were recruited from a zoo in Santa Barbara, CA. Verbal assent was obtained from participants in accordance with procedures approved by the University of California Santa Barbara Institutional Review Board (Protocol # 1-17-0996). We recruited 4- to 9-year-olds. Because we were interested in whether inferential abilities improve across development, we investigate age in two ways. First, we investigate age as a continuous factor in mixed effects logistic regression models. Second, if models reveal an effect of age, we analyze younger (4- to 6-year-olds) and older participants (7- to 9-year-olds) separately. We chose these age groups based on previous research suggesting the ability to reason about secrets, the type of personal knowledge used here, significantly improved from preschool to the early school years (Liberman & Shaw, 2018). Due to variability in the daily number of visitors to our testing site, we set our stopping criterion for data collection as the end of the day on which there were approximately 30 participants per age group for each study. We chose this sample size as our goal based on relevant prior research that collected data from similarly wide age ranges (e.g., Lockhart et al., 2016). We only collected demographic information about gender (to match the characters in the story to the child’s gender) and age. There were no repeat participants—children only participated in one of the three studies.

**Experiment 1: Friend vs. Schoolmate**

Experiment 1 compared inferences about friends and schoolmates and was a first pass at investigating if children use relationships to determine who knows what. We predicted that it would allow us to distinguish between at least two of three competing hypotheses. Specifically, if children do not use relationships to reason about shared knowledge (“No Inferences” hypothesis), then

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1 Prior to completing Experiment 1, we conducted a pilot experiment at the Museum of Science and Industry in Chicago, IL in the summer of 2016. The pilot study tested 3- to 11-year-olds using the same methods. The results with 4-to 9-year-olds were nearly identical to the results reported in Experiment 1. Please see the supplementary materials for a write up of the methods and findings for the pilot. Due to the typical ages of visitors in our new testing location, we decided to recruit only 4-to 9-year-olds before starting data collection for the reported studies.
participants should expect friends and schoolmates to be equally likely to share the main character’s knowledge. Or, if children think that people who are closer share more knowledge (“Closeness” hypothesis), then should always expect the friend to be more likely to share the main character’s knowledge. This study could also provide preliminary evidence for the “Selective Inferences” hypothesis, if children’s responses vary based on the knowledge type, but we investigate this hypothesis more fully in subsequent studies.

Method

Participants. 63 children participated (\(M_{\text{age}} = 6\) years 9 months; \(SD = 1\) year 9 months; \(n = 34\) females). This included 34 younger children (\(M_{\text{age}} = 5\) years 5 months; \(SD = 10\) months; \(n = 17\) females) and 29 older children (\(M_{\text{age}} = 8\) years 4 months; \(SD = 11\) months; \(n = 17\) females). Three additional participants were tested but excluded prior to analysis (\(n = 2\) for developmental disability, \(n = 1\) for experimental error).

Procedure. Participants were shown three gender-matched children, their faces placed in a triangle, with a main character on top, and two target characters on the bottom (see Figure 2). The experimenter introduced each of the bottom characters based on their relationship to the main character. One was the main character’s friend (who attended a different school), and the other was the main character’s classmate (but not a friend). The child on the left was always introduced first, but which relationship that target had with the main character was counterbalanced across participants.

Then, children were informed that the main character had three pieces of knowledge: Personal knowledge (“a secret”), Cultural knowledge (“how to celebrate Festivus”), and Moral knowledge (“hitting people is wrong”). For each piece of knowledge, the experimenter asked the participant who else knew it: the friend, the schoolmate, or both. Neither was not accepted as an option. If a participant did not immediately point to at least one of the characters, the question was repeated and they were prompted to select at least one option. The vast majority of children chose the first time the question was asked. The order of the three pieces of knowledge was counterbalanced. All participants were given a final knowledge question, designed to be relevant to the specific schoolmate.
relationship: knowledge of a school rule (“the rules [his/her] teacher made for [his/her] classroom”\(^2\)). This final piece of knowledge, which we call a “study-specific” piece of knowledge, was designed to potentially rule out the “Closeness” hypothesis and provide preliminary support for “Selective Inferences”: although friends might be more likely to share each of the other types of presented knowledge, a friend from another school should not be as likely to know classroom-specific rules.

For each type of knowledge, participants were scored based on whether they generalized the information to a friend (0 = no, 1 = yes), and whether they generalized the information to the schoolmate (0 = no, 1 = yes). Participants who responded that both children knew the knowledge were coded as saying “yes” for each partner.

**Results**

We first fit a mixed effects logistic regression model predicting the likelihood that the participant generalized the main character’s knowledge with age (in years, e.g., 4.38), social partner (friend vs. schoolmate), and knowledge type (personal vs. cultural vs. moral vs. school rule) as fixed factors. To control for repeated measures, we included subject as a random factor. The model revealed several significant three-way interactions between age, social partner, and knowledge type (see Table 1). These interactions suggest that children’s expectations varied based on both the type of knowledge and the type of relationship, so we next investigate the effect of relationship (and age) for each type of knowledge separately. For each type of knowledge, we conducted binomial tests asking whether children were above chance at generalizing the knowledge to each social partner. Since responding that both partners knew the information was coded as a “yes” for each partner, the likelihood of responding “yes” randomly for each social partner was 66%, so we used \(p = 0.66\) as chance level responding for all binomial tests (all reported \(p\)-values are two-tailed). We then used McNemar’s chi-squared tests with continuity correction to compare rates of generalizing the knowledge for each social partner.

Finally, to investigate effects of age, we fit additional mixed effects logistic regression models predicting the likelihood that the participant generalized that type of knowledge with age in years and relationship type (friend or schoolmate) as fixed factors. To control for repeated measures, we

\(^2\) It is possible that a school rule could be considered a type of “cultural knowledge” since it requires knowing the norms of the classroom. But, because it would only apply to the local culture of that classroom (rather than to a broader cultural group), we refer to it as “study-specific knowledge.”
included subject as a random factor. If the model revealed a significant effect of age or an interaction involving age, we analyze the two pre-determined age groups (younger participants: 4- to 6-year-olds, older participants: 7- to 9-year-olds) separately. To maintain greater power across the analyses, when there was no significant effect of age or interaction involving age, we do not include these additional analyses (but see Supplementary Materials for all analyses broken down by age, and see Figures 4 & 6, for significance of binomial probability tests for each type of knowledge for each age group).

**Personal knowledge.** Participants were above chance (66%) at generalizing personal knowledge to the friend (86%, binomial \( p < .001 \)) and below chance at generalizing personal knowledge to the schoolmate (40%, binomial \( p < .001 \); see Figure 3). Indeed, the pattern of responses differed across the two relationships (McNemar’s test \( p < .001 \)). According to a logistic regression, participants were marginally more likely to say the friend knew the secret (\( \beta = 3.2, SE = 1.91, p = .095 \)). This effect of relationship was qualified by a significant interaction between age and relationship (\( \beta = -.82, SE = .29, p = .006 \)), so we analyzed the data from each of our two pre-determined age groups.

**Younger children (4- to 6-year-olds).** Younger participants were above chance at expecting the friend to know the secret (82%, binomial \( p = .047 \)), but were at chance when responding about the schoolmate (56%, binomial \( p = .211 \); see Figure 4, left). Children’s rates of generalization were marginally different for friends compared to schoolmates (McNemar’s test \( p = .081 \)).

**Older children (7- to 9-year-olds).** Older participants were above chance expecting the friend (90%, binomial \( p = .006 \)), and below chance at expecting the schoolmate (21%, binomial \( p < .001 \); see Figure 4, right) to know the secret. These responses were significantly different for friends compared to schoolmates (McNemar’s test \( p < .001 \)).

Thus, young children understand that friends will share secrets, but have less clear expectations about schoolmates. Older participants, on the other hand, have a more robust understanding that friends will know each other’s secrets and that schoolmates will not.

**Cultural knowledge.** Participants were at chance at expecting both the friend (76%, binomial \( p = .110 \)), and the schoolmate (71%, binomial \( p = .426 \)) to know the same cultural knowledge as the main character (see Figure 3). Indeed, they generalized cultural knowledge at similar rates for the two social partners (\( p = .73 \); McNemar’s test). The logistic regression model revealed that neither age,
relationship, nor their interaction significantly predicted children’s responses (all \( p \)'s > .126). Therefore, participants did not have clear expectations about cultural knowledge.

**Moral knowledge.** Participants were above chance at generalizing moral knowledge to the friend (81%, binomial \( p = .011 \)) but were at chance at generalizing it to the schoolmate (75%, binomial \( p = .183 \); see Figure 3). However, participants’ responses were similar for the two social partners (\( p = .571 \); McNemar’s test). According to the logistic regression model, neither relationship, age, nor their interaction predicted participants’ generalizations of moral knowledge (all \( p \)'s > .387). Overall, participants showed high levels of generalizing moral knowledge.

**School knowledge.** Participants were marginally above chance at expecting the schoolmate to know the classroom rules (78%, binomial \( p = .062 \)), and were significantly below chance at expecting the friend to know them (44%, binomial \( p < .001 \); see Figure 5). Participants were significantly more likely to generalize school-specific knowledge to the schoolmate (\( p = .005 \); McNemar’s test). The logistic regression model confirmed that children were more likely to say the schoolmate possessed the school knowledge (\( \beta = -5.64, SE = 1.90, p = .003 \)). Younger children were more likely to generalize knowledge overall (\( \beta = -.78, SE = .21, p < .001 \)), and there was a significant interaction between age and relationship (\( \beta = 1.07, SE = .29, p < .001 \)). Because of these age effects, we report here the pre-determined age groups separately.

**Younger children (4- to 6-year-olds).** Younger participants were at chance at expecting the friend (68%) and the schoolmate (71%) to know the classroom rules (binomial \( p \)'s > .71; see Figure 6, left). They were equally likely to report that the friends and schoolmates knew the classroom rules (\( p = 1 \); McNemar’s test).

**Older children (7- to 9-year-olds).** Older participants, on the other hand, expected the classmate to know the school rule (86%, binomial \( p = .029 \)), and expected the friend not to know it (17%, binomial \( p < .001 \); see Figure 6, left). They were significantly more likely to generalize knowledge of the school rule to the classmate (\( p < .001 \); McNemar’s test). While younger children did not make clear inferences regarding who should know school-specific rules, older children robustly inferred that the schoolmate—not the friend—would know the rules of the main character’s classroom.

**Discussion**
The results of Experiment 1 suggest that, while older children’s responses were more robust than younger children’s, children in both age groups use relationships to make inferences about knowledge. Although relationships did not impact children’s responses about cultural knowledge (where children were at chance at generalizing both to friends or classmates) or moral knowledge (where generally expected people to know that hitting was wrong), children did take relationships into account when reasoning about personal and school knowledge. Thus, these data provide strong evidence against the “No Inferences” hypothesis.

Indeed, results revealed preliminary support for the “Selective Inferences” hypothesis, at least for older children. Older participants (7- to 9-year-olds) expected friends (and not schoolmates) to know each other’s secrets, and expected schoolmates (but not friends) to know school rules. Thus, older children readily infer that relationships influence shared knowledge, and that the type of relationship determines the type of knowledge shared.

But, younger participants (4- to 6-year-olds) showed a different pattern of results. Although they expected friends to be marginally more likely to know secrets than schoolmates, they did not expect relationships to impact school knowledge. Because personal knowledge was the only case in which younger children differentiated their expectations based on relationships, Study 1 cannot rule out that younger children’s reasoning is in line with the “Closeness” hypothesis: young children may initially make inferences based on closeness, and only later come to understand that different relationships lead to different types of shared knowledge. However, because younger children have limited experience in school, they may have a limited understanding of the relationship “schoolmate”. Indeed, they might anticipate that all classmates are friends (despite our noting that they were not friends), leading to less differentiated responses. Therefore, we next asked children to make inferences about a different type of social relationship – cultural group membership.

**Experiment 2: Friend vs. National Group Member**

In Experiment 2 we compared friends and national groupmates. We chose these relationships for a couple of reasons. First, children expect members of a group (but not people outside the group) to conform to the group’s cultural customs. By age three, children protest when ingroup (but not outgroup) members break a rule (e.g., Schmidt, Rakoczy, & Tomasello, 2012) and predict that group membership will guide culturally-specific conventional (but not moral) behaviors (e.g., Liberman,
Howard, Vasquez, & Woodward, 2018). Therefore, children may selectively generalize cultural knowledge to people in the same group. Additionally, this comparison allows us to clearly distinguish between the “Closeness” hypothesis and the “Selective Inferences” hypothesis. The “Closeness” hypothesis would predict that knowledge (regardless of type) would be more likely to be shared between friends, than (non-friend) groupmates. However, the “Selective Inferences” hypothesis would predict members of the same national group would be more likely to share cultural knowledge. We chose nationality to mark culture because prior work has shown that, by age five, children understand that national group labels indicate properties of people in those groups (i.e., they classify English speakers as “American,” and Korean speakers as “Korean;” DeJesus, Hwang, Dautel, & Kinzler, 2018) and because children use “living nearby” versus “living far away” as a meaningful symbol of social group (McLoughlin & Over, 2017; McLoughlin, Tipper, & Over, 2018. Additionally, manipulating nationality, rather than another marker of group membership (e.g., language, race), allowed us to use the same stimuli as in Experiment 1.

Method

Participants. 84 children ($M_{age} = 6$ years 8 months; $SD = 1$ year 9 months; 47 females) participated. This included 52 younger children ($M_{age} = 5$ years 6 months; $SD = 10$ months; 28 females) and 32 older children ($M_{age} = 8$ years 7 months; $SD = 11$ months; 19 females). Prior to analysis, the data from four additional participants were excluded ($n = 2$ for parental interference, $n = 1$ for developmental disability, and $n = 1$ for previously participating in Study 1).

Procedure. The procedure was identical to Experiment 1 except for the relationships: One character was described as the main character’s friend (from a different country) and the other was described as (a non-friend) from the same country as the main character (see Appendix 2 for script). Novel national group names were used to control for participants’ exposure to information about any one national group. After asking about personal, cultural, and moral knowledge, participants were asked a “study-specific” knowledge question that involved a second type of cultural knowledge: nation-specific knowledge (“Who else knows the national song of Cortania?”). Although we did not predict different responses for cultural knowledge and national-specific knowledge, we included

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3 The novel national group names used were Cortania (taken from DeJesus, Gerdin, Sullivan, & Kinzler, 2019) and Tamsena (taken from Heiphetz, Spelke, Harris, & Banaji, 2013)
nation-specific knowledge to be a type of cultural knowledge that should be specifically shared between people who are from the same national group (holidays can be celebrated by people from different nations, and are not always celebrated by all members of a national group—for example Christmas is celebrated across the world, but not by everyone in the United States). For each question, participants were asked to generalize the knowledge to the friend, the national groupmate, or both.

**Results**

We first fit a mixed effects logistic regression model predicting the likelihood that the participant generalized the main character’s knowledge with age (in years), social partner type (friend vs. groupmate), and knowledge type (personal vs. cultural vs. moral vs. national anthem) as fixed factors. To control for repeated measures, we included subject as a random factor. The model again revealed significant three-ways interactions involving age, social partner, and type of knowledge (see Table 1). Therefore, we completed the same follow-up analyses as in Experiment 1, investigating each type of knowledge separately.

**Personal knowledge.** Participants were above chance at expecting the friend to know the secret (79%, binomial \( p = .015 \)), and were below chance at expecting the national ingroup member to know (44%, binomial \( p < .001 \); see Figure 3). These patterns of generalization were significantly different \( (p < .001; \text{McNemar’s test}) \). The logistic regression model revealed that children were marginally more likely to say that the friend knew the secret \( (\beta = 2.82, \text{SE} = 1.48, p = .056) \). This effect was qualified by a significant interaction between age and relationship \( (\beta = -.66, \text{SE} = .22, p = .003) \). To better comprehend this age effect, here we separately report the data from our two predetermined age groups.

**Younger children (4- to 6-year-olds).** Younger children were at chance at generalizing the secret to the friend (77%, binomial \( p = .108 \)), and were marginally below chance at generalizing the secret to the national group member (54%, binomial \( p = .078 \); see Figure 4, left). These patterns of response were marginally different from one another \( (p = .067; \text{McNemar’s test}) \). Replicating Study 1, young children held a weak expectation that friends would be more likely to know each other’s secrets.

**Older children (7- to 9-year-olds).** Older participants were marginally above chance at generalizing to the friend (81%, binomial \( p = .091 \)), and were significantly below chance at...
generalizing to the national group member (28%, binomial $p < .001$; see Figure 4, right). These patterns of responses were different from one another ($p = .003$; McNemar’s test). Thus, children become more likely with age to infer that (non-friend) national groupmates would not know one another’s secrets.

**Cultural knowledge.** Participants were above chance at expecting the national group member to know the cultural knowledge (82%, binomial $p = .002$), but were at chance when asked whether the friend would know it (57%, binomial $p = .11$; see Figure 3). Participants’ responses again differed by social relationship (McNemar’s test $p = .005$). According to the logistic regression model, there was a significant effect of age ($\beta = -.31$, SE = .14, $p = .021$), and a marginal effect of relationship ($\beta = -2.84$, SE = 1.53, $p = .063$). Both of these effects were qualified by a significant interaction between age and relationship ($\beta = -.62$, SE = .23, $p = .008$). To understand the influence of age, we separately report the data from each of our two pre-determined age groups.

**Younger children (4- to 6-year-olds).** Younger participants were at chance when generalizing cultural knowledge to the child’s friend (65%, binomial $p = 1$) and to national ingroup member (77%, binomial $p = .108$; see Figure 4, left). These patterns of results did not differ based on relationship ($p = .361$; McNemar’s test). Younger children did not express clear expectations regarding who would know the main character’s cultural customs.

**Older children (7- to 9-year-olds).** On the other hand, older participants were significantly above chance at generalizing cultural knowledge to the ingroup member (91%, binomial $p = .002$) and significantly below chance at generalizing cultural knowledge to the friend (44%, binomial $p = .014$; see Figure 4, right). These patterns were significantly different from one another ($p = .002$; McNemar’s test). Thus, older children clearly expected national groupmates, but not friends from other national groups, to know the groups’ cultural customs.

**Moral knowledge.** Participants were significantly above chance at generalizing moral knowledge to the friend (85%, binomial $p < .001$) and were marginally above chance at generalizing moral knowledge to the national groupmate (75%, binomial $p = .085$; see Figure 3). The pattern of generalization did not vary based on the partner type ($p = .23$; McNemar’s test). According to the logistic regression model, participants’ responses were not predicted by age, relationship, or their
interaction ($p’s > .37$), suggesting that as in Experiment 1, participants of all ages were similarly likely to think that both social partners would possess moral knowledge.

**National knowledge.** Participants were above chance at generalizing knowledge of the country’s national anthem to the groupmate ($83\%$, binomial $p < .001$), and were below chance at generalizing this knowledge to the friend ($35\%$, binomial $p < .001$; see Figure 5). Indeed, these patterns of responses differed significantly ($p < .001$; McNemar’s tests). According to the logistic regression model, there were significant effects of relationship ($\beta = -3.42$, SE = 1.66, $p = .04$), age ($\beta = - .63$, SE = .18, $p < .001$), and their interaction ($\beta = .88$, SE = .26, $p < .001$). To better understand the effect of age, we analyzed the data from each age group separately.

**Younger children (4- to 6-year-olds).** Younger participants were above chance at saying that the national groupmate would know their shared native country’s national anthem ($81\%$, binomial $p = .03$), and were below chance at generalizing this knowledge to the friend ($46\%$, binomial $p = .004$; see Figure 6, left). These patterns of responses differed significantly from each other ($p = .006$; McNemar’s test). Even the youngest participants selectively inferred that national groupmates, not friends, would know nation-specific information.

**Older children (7- to 9-year-olds).** Older participants were also significantly above chance at saying that the national groupmate would know their shared native country’s national anthem ($88\%$, binomial $p = .009$), and significantly below chance at generalizing this knowledge to the friend ($16\%$, binomial $p < .001$; see Figure 6, right). These responses were significantly different based on relationship ($p < .001$; McNemar’s test). Older participants were even less likely than younger participants to expect a friend from a national outgroup would know nation-specific knowledge.

**Discussion**

This study provides further evidence for the “Selective Inferences” hypothesis: Children use information about relationships when inferring who possesses knowledge, and this ability strengthens with age. As in Experiment 1, children’s responses were not random with regards to the relationship, continuing to provide evidence against the “No Inferences” hypothesis. And, children’s responses varied based on the type of knowledge: They did not always choose the friend as being more likely to share the knowledge, providing evidence against the “Closeness” hypothesis. In fact, children understood that different types of relationships license different types of shared knowledge. All
children expected national groupmates to be more likely than friends (from different national groups) to share national knowledge, and older children also expected national groupmates to be more likely than friends to share cultural knowledge. Further, older children expected friends to be more likely than national groupmates to share secrets. Moreover, children of all ages understood that some types of knowledge are not contingent on social relationships: As in Experiment 1, children expected both friends and groupmates to know moral rules.

However, we continued to find different reasoning across development, such that older children’s expectations were more in line with the “Selective Inferences” hypothesis than younger children’s expectations. For example, although older children (7- to 9-year-olds) expected national groupmates (but not friends) to have shared cultural knowledge, younger children did not significantly differentiate cultural knowledge based on relationships. However, younger participants’ responses conform to the “Selective Inference” hypothesis in some cases: they expected national groupmates to be more likely to know nation-specific knowledge than friends and expected friends to be marginally more likely than national groupmates to know the main character’s secret. From this single case, we cannot rule out that younger children are not reasoning based upon closeness. Overall, older children’s responses strongly support the “Selective Inferences” hypothesis, whereas younger children’s responses show weaker support.

**Experiment 3: Friend vs. Sibling**

To further explore children’s intuitions about knowledge and relationships, Experiment 3, asked which types of knowledge children expect siblings to share. Siblings are interesting because they share features of friends (e.g., spending a lot of time interacting closely) and group members (e.g., being from the same cultural background). We compared children’s expectations about the main character’s (non-sibling) friend and her (non-friend) sibling. Although children may typically be friends with their siblings, we purposefully differentiated the relationships to test for selective inferences. For the study-specific knowledge question we included a piece of family-specific knowledge (when bedtime is in the main character’s house). The results of this question may help further adjudicate between the “Closeness” hypothesis and the “Selective Inference” hypothesis. Under the “Closeness” hypothesis, children may expect both friends and siblings to know the family specific knowledge, since they are both close relationships. But, under the “Selective Inferences”
hypothesis, children should understand that family-specific knowledge would be more likely to be shared by siblings than by friends.

**Method**

**Participants.** 71 children participated ($M_{age} = 6$ years 8 months; $SD = 1$ year 10 months; 49 females). This included 35 younger participants ($M_{age} = 5$ years 0 months; $SD = 10$ months; 24 females) and 36 older participants ($M_{age} = 8$ years 4 months; $SD = 9$ months; 25 females). Prior to analysis, two additional participants were excluded (due to experimental error).

**Procedure.** The procedure was identical to Experiments 1 & 2, except the relationships were the main character’s friend (from a different family), and the main character’s (non-friend) sibling (see Appendix 3 for script). After being asked about personal, cultural, and moral knowledge in a counterbalanced order, participants were asked about a piece of “study-specific” knowledge that we expected would be viewed as specific to the sibling (“when is bedtime”).

**Results**

We first fit a mixed effects logistic regression model predicting the likelihood that the participant generalized the main character’s knowledge with age (in years), social partner type (friend vs. sibling), and knowledge type (personal vs. cultural vs. moral vs. bedtime) as fixed factors. To control for repeated measures, we included subject as a random factor. The model again revealed significant three-way interactions involving age, social partner, and type of knowledge (see Table 1). Therefore, we completed the same follow-up analyses as in Experiments 1 and 2, investigating each type of knowledge separately.

**Personal knowledge.** Participants were at chance at expecting the friend (72%) and the sibling (63%) to know the secret (binomial $p$’s > .32; see Figure 3), and were equally likely to generalize personal knowledge to each partner (McNemar’s test $p = .461$). Neither age, relationship, nor their interaction predicted responses ($p$’s > .32). Participants considered friends and siblings to be similarly likely to know one another’s secrets, perhaps because both are close affiliates.

**Cultural knowledge.** Participants were above chance at expecting siblings to possess shared cultural knowledge (78%, binomial $p = .045$), and were below chance at expecting the friend to know the cultural knowledge (54%, binomial $p = .033$; see Figure 3). The patterns of responses varied for the two relationships (McNemar’s test $p = .022$). The logistic regression model confirmed that
children were marginally more likely to say that siblings would share cultural knowledge ($\beta = 2.64$, $SE = 1.45$, $p = .069$), and revealed no effect of age, and no interaction between age and social relationship ($p$’s $> .26$).

**Moral knowledge.** Children were above chance at expecting friends to possess moral knowledge (85%, binomial $p < .001$), but were at chance at expecting the sibling to know that hitting was wrong (63%, binomial $p = .62$; see Figure 3). Indeed, participants were more likely to say the friend would possess moral knowledge (McNemar’s test $p = .021$). However, according to the logistic regression model, neither age, relationship, nor their interaction predicted responses ($p$’s $> .24$).

**Family knowledge.** Participants were above chance at expecting the sibling to know bedtime (85%, binomial $p < .001$), and were below chance at expecting the friend to know it (52%, binomial $p = .016$; see Figure 5). Participants’ responses varied across the social partners (McNemar’s test $p < .001$). According to the logistic regression model, there was a significant effect of age ($\beta = -.32$, $SE = .14$, $p = .023$), qualified by a significant interaction between age and relationship ($\beta = .52$, $SE = .23$, $p = .027$). To shed light on these age effects, we report below separate analyses based on the two predetermined age groups.

**Younger children (4- to 6-year-olds).** Younger participants were at chance at expecting the friend (66%, binomial $p = 1$) or the sibling (80%, binomial $p = .107$; see Figure 6, left) to know bedtime. They generalized family knowledge to both partners at similar rates ($p = .359$, McNemar’s test).

**Older children (7- to 9-year-olds).** Older participants were above chance at expecting the sibling to know bedtime (89%, binomial $p = .003$), and were below chance at expecting the friend to know it (39%, binomial $p = .002$; see Figure 6, right). These patterns of responses differed significantly ($p < .001$, McNemar’s test). Older participants robustly reported that siblings would know family-specific information, but friends would not.

**Discussion**

This study provided further evidence for the “Selective Inferences” hypothesis. Although there were many similarities in how children reasoned about friends and siblings, there were also concrete differences. For instance, children of all ages expected siblings to be more likely than friends to have shared cultural knowledge, and expected friends to be more likely than siblings to have shared moral
knowledge. Older children also expected siblings to be more likely than friends to know the house rules. Although children’s reasoning about morality was somewhat unexpected, it provides further evidence against the “Closeness” hypothesis (since children are differentiating between two types of highly close relationships) and could reflect children’s own experiences with their siblings (e.g., getting into fights).

These results are interesting in that they are among the first evidence that young children differentiate between friends and family. Although previous research found that children value friends and family over strangers (Olson & Spelke, 2008; Spokes & Spelke, 2016), children typically behave similarly towards friends and family (but see Spokes & Spelke, 2018 for one example where the two are treated differently). Finally, as in the previous experiments, many effects got stronger with age, indicating that older children show greater support than younger children for the “Selective Inferences” hypothesis.

General discussion

Across three experiments, we find support for the “Selective Inferences” hypothesis: Children, particularly 7- to 9-year-olds, consider both the knowledge type and the targets’ relationships when inferring who knows what. Children expect some types of knowledge to be widely shared (e.g., moral) and expect social relationships to constrain other types of knowledge. For example, friends spending time together and create intimacy, fostering shared personal knowledge (e.g., Bigelow, 1977). And, cultural group members may not know one another personally, but are bound by shared norms (e.g., Whitehouse & Lanman, 2014). In line with the different social interactions involved in these relationships, older children believe friends will be more likely to know each other’s secrets, and national group members will be more likely to share cultural knowledge (e.g., about holidays, or national songs). Interestingly, older children expect siblings to share similarities with both groupmates and friends: They expect siblings (typically from the same cultural group) to share cultural knowledge, and to be more likely to share personal knowledge (e.g., children are at chance at generalizing personal knowledge to the sibling, but are below chance at generalizing personal knowledge to a groupmate).

Although children of all ages tested gave responses in line with the “Selective Inferences” hypothesis, the selectivity of children’s responses was robust only in older children (7- to 9-year-
olds). For instance, older participants were less likely to expect schoolmates and groupmates to know someone’s secret. Age-related differences in children’s ability to reason about personal knowledge replicate Liberman & Shaw (2018): Older children are more likely to expect secrets to be shared selectively with friends. Older children also showed more differentiation based on relationships in all study-specific questions (Figure 6, right). With age, children may become more adept at understanding nuances of how social relationships impact shared knowledge. Age-related developments may be related to greater ability to understand how people gain knowledge (e.g., Lockhart et al., 2016), and to increased experience in navigating differentiated relationships. For example, as children gain experience participating in varied social relationships (e.g., having close friends, acquaintances, and even disliked peers), they might increasingly realize that not everyone who knows each other shares all types of knowledge (e.g., children may not share all of their secrets with parents). This possibility is in line with the idea that the developmental differences we observed are driven by changes in children’s sociological understanding.

While children’s inferences become more selective with age, it is worth noting that even the youngest age group tested demonstrated the seeds of the ability to use social relationships to infer who knows what. Younger children’s inferences were not in line with “No Inferences” hypothesis (they differentiated based on relationship) or a “Closeness” hypothesis (younger children did not always attribute shared knowledge to the socially closer character). For example, younger children expected friends to be more likely to share personal knowledge, but expected groupmates to share national knowledge (Figures 4 & 6). These results are particularly interesting given early difficulties at monitoring sources of knowledge (e.g., Birch & Bloom, 2003; Taylor, Esbensen, & Bennett, 1994). Yet, our findings with younger children are notably weaker than those with older children, and further research is necessary to understand younger children’s relationship-based inferences about knowledge. Perhaps changes in children’s sociological understanding in early childhood move them towards reasoning selectively. In this case, our weaker results from younger children may reflect a transition point between reasoning based on closeness to reasoning based on specific relationships.

It is important to note that these results provide information about who children expect to share knowledge, but not evidence of how children think individuals came by their knowledge. For example, when children state that the main character and her groupmate share cultural knowledge,
they could be reasoning specifically about knowledge transfer (e.g., the characters learned the knowledge from a shared-source, such as a cultural group leader). But, they could be reasoning that because the individuals are in the same category, they will share category-specific properties (including category knowledge). Future research is needed to determine how children expected shared knowledge to develop, and to differentiate between knowledge per se, and other properties that are shared when people are in relationships and groups.

Future research should also investigate how different types of relationships (e.g., friends vs. group members) impact children’s broader social inferences. Although these affiliations are similar in some ways (e.g., children show favoritism towards friends (Birch & Billman, 1986; Olson & Spelke, 2008; Moore, 2009) and in-group members (e.g., Dunham, Baron, & Carey, 2011)), we found that children expected people in different relationships to have different knowledge. In order to test for differentiated reasoning, we clearly told children that the characters were in one type of relationship, but not another (e.g., a friend from a different national group). Future research can investigate children’s inferences when only one relationship is discussed (e.g., if children think friends tend to be members of the same social group it may impact their reasoning about shared knowledge between friends).

Future work could also further probe children’s reasoning about knowledge. We tested three broad types of knowledge using specific examples (e.g., how to celebrate a holiday for cultural knowledge). But, future research could test different examples for each knowledge type (e.g., a personal fact, such as a birthday for personal knowledge; knowledge of a different moral norm), and even different broad categories of knowledge (e.g., expertise). We predict that children may use their understanding of how knowledge is transferred in order to make predictions about who knows what. For example, children may expect (1) friends and family members to share knowledge that is gained in interpersonal interaction, (2) groupmates to share knowledge that is gained in group-relevant contexts (e.g., religious group members would share religious knowledge; people from the same country would share national knowledge), and (3) experts to share knowledge that is gained through training in their expertise.

In sum, our work highlights an early understanding of the sociality of shared knowledge that grows across development. Moreover, these findings open many exciting directions for future
research. Remarkably, despite early limitations in understanding some aspects of knowledge (e.g., source monitoring: Birch & Bloom, 2003; Taylor, Esbensen, & Bennett, 1994), young children make powerful inferences about others’ knowledge based on the nature of their social relationships.

References


Spokes, A.C., & Spelke, E.S. (2018). At 4.5 but not 5.5 years, children favor kin when the stakes are moderately high. *PLOS ONE, 13*(8), e0202507.


Figure Captions

Figure 1. Graphs showing predicted patterns based on the three hypotheses. Scores are directional (e.g., above or below chance), but are not intended to estimate the strength of the pattern, and are not based on a computational model. For example, the Selective Inferences hypothesis posits that children will be above chance at expecting that friends share personal knowledge and below chance at expecting schoolmates or groupmates to share personal knowledge.

Figure 2. Target images shown to participants in all three experiments. Images were gender-matched to the participant. Stimuli are from Kinzler, Shutts, DeJesus & Spelke, 2009.

Figure 3. Results of Experiments 1-3 for the personal, cultural, and moral knowledge. For all the graphs depicting results, the y-axis is the rate at which participants generalized knowledge to each social partner (labeled on x-axis), the dashed line indicates chance (66%), stars indicate that participants’ responses significantly differed from chance (binomial probability tests, \( p < .05 \)), and tildes indicate that participants’ responses were marginally different from chance (\( p < .1 \)). Since participants were asked about friends in all three experiments, in Figures 3 and 4 the friend results (leftmost bars) indicate the combined rate at which participants generalized knowledge to the friend across all three experiments.

Figure 4. Results from younger children (4- to 6-year-olds; left) and older children (7- to 9-year-olds) in Experiments 1-3 for the personal, cultural, and moral knowledge.

Figure 5. Results of “study-specific” questions: school-specific knowledge (Experiment 1), nation-specific knowledge (Experiment 2), and family-specific knowledge (Experiment 3).

Figure 6. Results from younger children (4- to 6-year-olds; left) and older children (7- to 9-year-olds; right) for the study-specific knowledge.

Tables

Table 1
<table>
<thead>
<tr>
<th>Predictor</th>
<th>Study 1</th>
<th>p-value</th>
<th>Study 2</th>
<th>p-value</th>
<th>Study 3</th>
<th>p-value</th>
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<td>4.46 (2.13)</td>
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<td>0.029*</td>
<td>-0.78 (0.33)</td>
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Table 1. Results of the initial regression models completed for Experiments 1-3. For all models, the study-specific knowledge (school, nation, family) was set as the baseline level for knowledge, and friend was set as the baseline level for relationship. *p < .05, **p < .01, ***p < .001.

Appendix 1

Experiment 1 (Friend vs. Schoolmate) Sample Script

In this game, I am going to tell you about some people and then ask you some questions. Are you ready?

Introduction: This girl [top] and this girl [left] are friends. They hang out because they really like to play together, but they don’t go to the same school. They are not schoolmates. This girl [top] and this [left]...

---

4 All appendices include example scripts that were used with female participants. Scripts and visual stimuli were gender-matched to the participant for all three experiments. Also, the order of presentation of the target children (friend, schoolmate, etc.) was always counterbalanced across participants, as were the first three questions. Bracketed words refer to pointing instructions for the experimenter. Experimenter pointed to the face they were directed to by the brackets.
girl [right] go to school together. They hang out because their teacher makes them sit next to each other in class. But, they are not friends.

1) **Personal knowledge:** This girl [top] has a secret. Who else knows it? This girl [left]? This girl [right]? Or both these girls?

2) **Cultural Knowledge:** This girl [top] knows how to celebrate Festivus. Who else knows how to celebrate festivus? This girl [left]? This girl [right]? Or both these girls?  

3) **Moral Knowledge:** This girl [top] knows that hitting people is wrong. Who also knows that hitting people is wrong? This girl [left]? This girl [right]? Or both these girls?

4) **School Knowledge:** This girl [top] knows the rules in her classroom. Who also knows the rules in her classroom? This girl [left]? This girl [right]? Or both these girls?

**Appendix 2**

Experiment 2 (Friend vs. National Group) Sample Script

In this game, I am going to tell you about some people and then ask you some questions. Are you ready?

**Introduction:** This girl [top] is from Cortania, and this girl [left] is from Tamsena. These two girls [top and left] hang out because they really like to play together. They are not from the same place, but they are friends. This girl [top] is from Cortania, and this girl [right] is also from Cortania. These two girls [top and right] hang out because they are from the same place, but they are not friends.

1) **Personal knowledge:** This girl [top] has a secret. Who else knows it? This girl [left]? This girl [right]? Or both these girls?

2) **Cultural Knowledge:** This girl [top] knows how to celebrate Festivus. Who else knows how to celebrate Festivus? This girl [left]? This girl [right]? Or both these girls?

3) **Moral Knowledge:** This girl [top] knows that hitting people is wrong. Who also knows that hitting people is wrong? This girl [left]? This girl [right]? Or both these girls?

5 At the very end of the study, the first 25 participants were asked whether they knew what Festivus was. This was to check whether knowledge of this fake holiday (a reference from *Seinfeld*) mattered. Most kids reported not knowing, thus confirming we had picked a novel holiday name. Whether or not they knew did not impact results.
4) **National Knowledge**: This girl [top] knows the national song of Cortania. Who also knows the national song of Cortania? This girl [left]? This girl [right]? Or both these girls?

---

**Appendix 3**

Experiment 3 (Friend vs. Sibling) Sample Script

In this game, I am going to tell you about some people and then ask you some questions. Are you ready?

**Introduction**: This girl [top] and this girl [left] are friends. They hang out because they really like to play together, but they don’t live in the same house. They are not sisters. This girl [top] and this girl [right] are sisters. They hang out because they live in the same house. But, they are not friends.

1) **Personal Knowledge**: This girl [top] has a secret. Who else knows it? This girl [left]? This girl [right]? Or both these girls?

2) **Cultural Knowledge**: This girl [top] knows how to celebrate Festivus. Who else knows how to celebrate Festivus? This girl [left]? This girl [right]? Or both these girls?

3) **Moral Knowledge**: This girl [top] knows that hitting people is wrong. Who also knows that hitting people is wrong? This girl [left]? This girl [right]? Or both these girls?

4) **Family Knowledge**: This girl [top] knows when bedtime is in her house. Who also knows when bedtime is in her house? This girl [left]? This girl [right]? Or both these girls?
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Results: Study-specific questions

Percentage Correct in Knowledge

- School (Study 1)
- Nation (Study 2)
- Family (Study 3)

* Significance

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